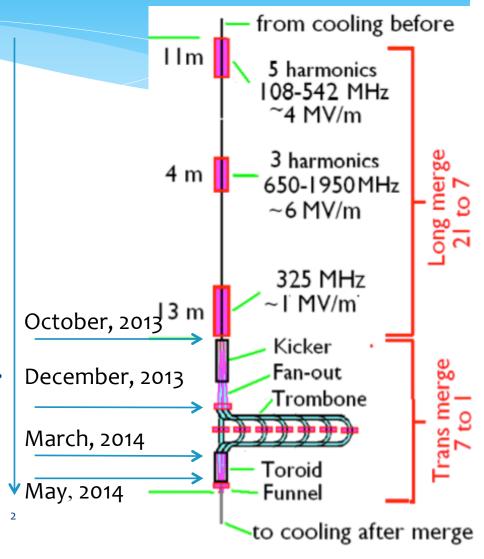
End-to-end simulation of Bunch merge

Yu Bao
UC Riverside
MAP Collaboration meeting
Dec. 4, 2014

overview

- MOctober,2013: Longitudinal merge using ideal rf field finished.
- March, 2014: Trombone designed, EmitT conserved.
- May, 2014: Funnel simulated.
- Magust, 2014: New trombones with RF cavities.
- 👿 Dec, 2014: End to end



Longitudinal Merge

The rf fields are simulated by analytic expressions.

The harmonics are superpose on each other and the total field is:

$$E_z = \sum Grad_i \sin(2\pi t f_i - 2\pi f_i z / v_{ref} + \varphi_i)$$

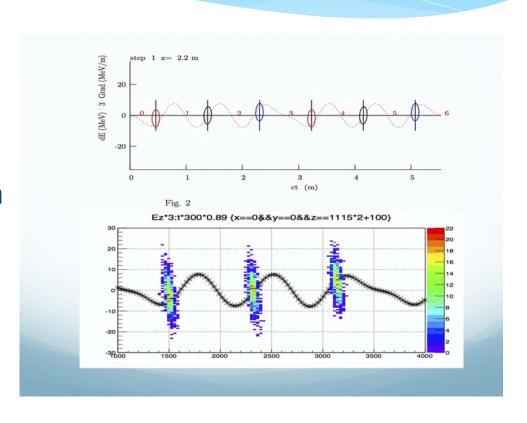
Where avegrad_i, freq_i and phase_i are given in the table (only one cavity parameters are shown):

stage	k	icay.	L m	f MHz	phase deg	avegrd MV/m	locgrad MV/m	<u>cavstrt</u> cm	lcavlen cm	sumL cm
1 0 1 0 1 0 1 0 1 0)	1 1 1 1	1.115 1.115 1.115 1.115 1.115	108.33 216.67 325.00 433.33 541.67	182.44 2.10 180.73 179.53 3.01	-0.222 -0.516 -2.010 -1.113 -0.281	5.383 10.376 12.708 14.674 16.406	8.692 18.338 40.073 52.627 58.635	4.59 5.55 17.64 8.45 1.91	0.00 0.00 0.00 0.00 56.73

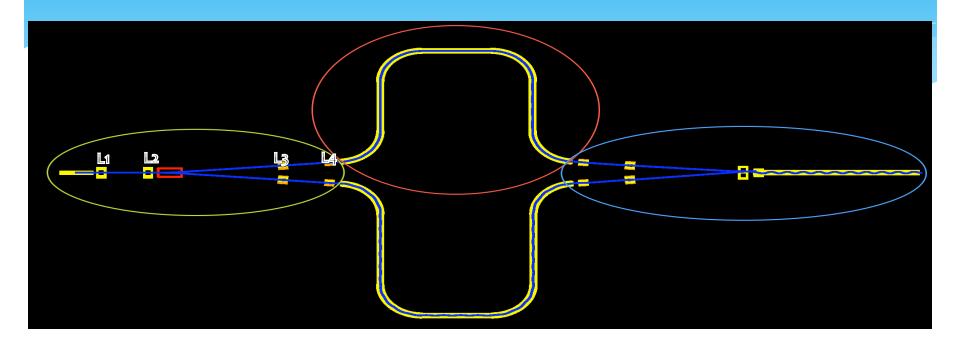
Longitudinal Merge Process

- **M**92% transmission
- SigmaP = 8.9 MeV/c (input 7.51 MeV/c)

- SigmaX'=SigmaY'=0.03 (input 0.03)
- W EmitT=1.6 mm
- **™**EmitL=8.5 mm

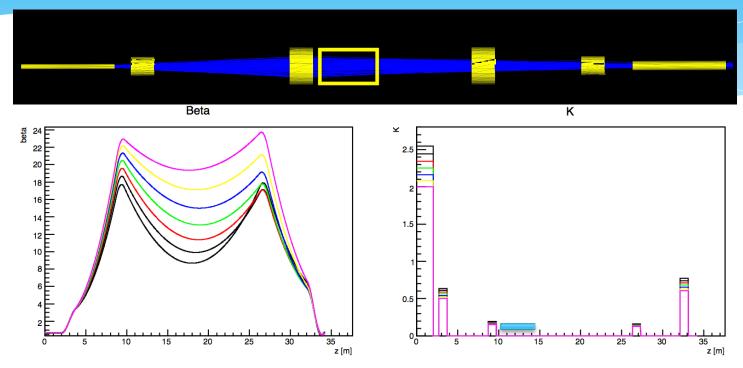


Transverse Merge



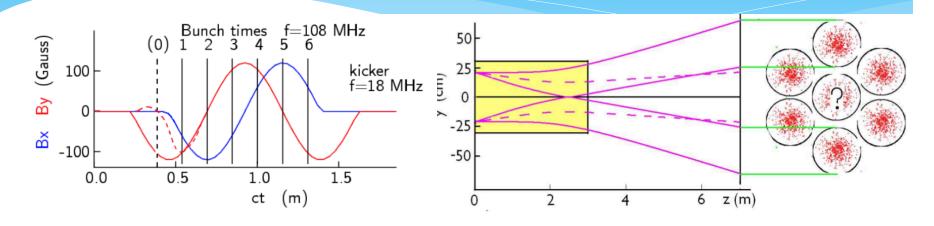
- **Kicker & Matching:** kicks the beam to the trombones.
- Trombones: lead the bunches to different paths.
- **Funnel**: collect the bunches at the same time.

Matching channel (w/o kicker)



- Matching the beam from longitudinal merge to the trombones.
- Optimized by propagating the Courant-Snyder parameters.

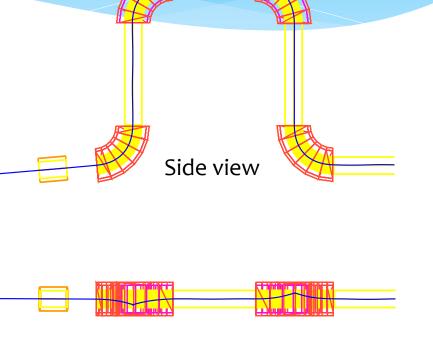
Kicker



- Periodic magnetic fields in both x and y directions
- Kicking bunches to 6(7) different Trombones with different lengths to bring them to the Funnel at the same time.
- 🕅 Fan out drift: 17 m

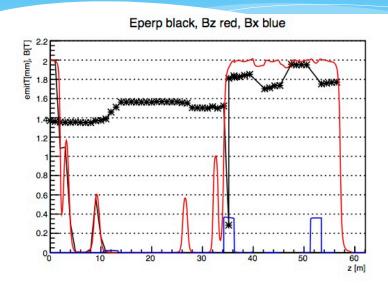
Trombone (Original design)

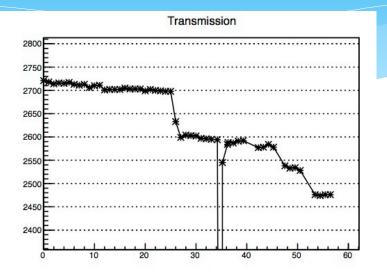
- ☑ Dipoles outside bent solenoids.
- Will Using arms to matching the 7 beams.
- **™**R=1.41m, L=2.2m
- **™** Dipole field B=0.36T



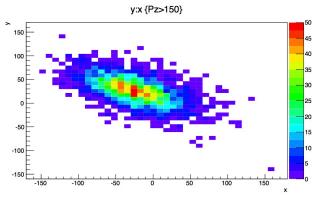
Top view

Results

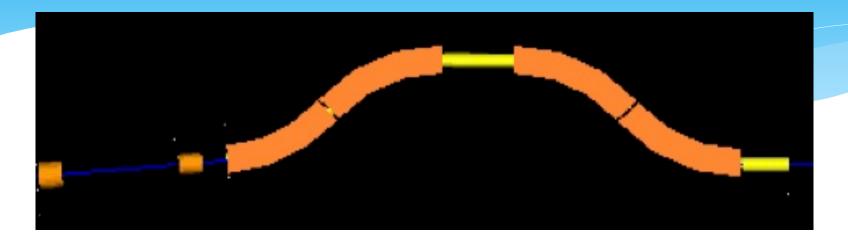




- Transverse emittance (EmitT):1.78mm
- Transmission: 81%
- Ellipse beam shape, off axis -> Can't fit into later funnel.
- Large bending radius can solve the problem.



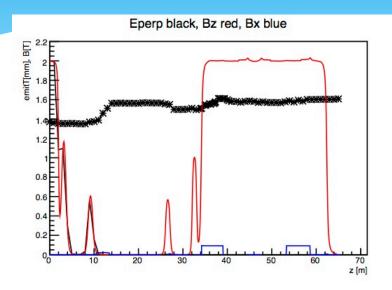
Take out straight arms

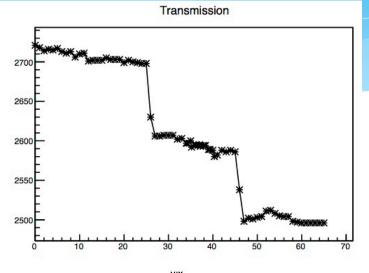


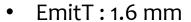
- Use the same large bending radius, but different angles for the trombones
- Separation of the first and last bunch is 6*2464mm
- The longest trombone with four 90 degree bending separating the first and last bunch has a radius R=6476.8mm
- Other trombones with bending angle Theta has the same radius R, and : 4*Theta*R 4*R*sin(Theta) = N*2464mm

Plot above is N=1

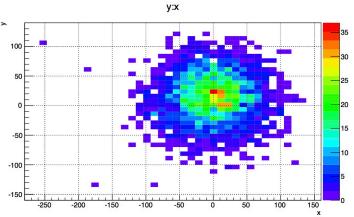
Results



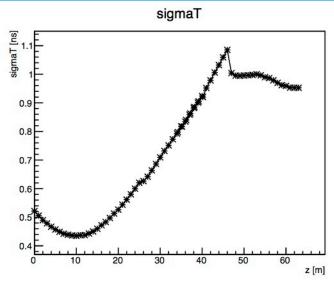




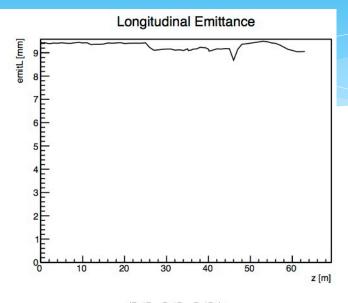
- Transmission: 83%
- Beam profile is round, and centered.
- Shown above N=1, others are the same

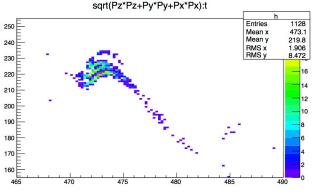


RF cavity and EmitL

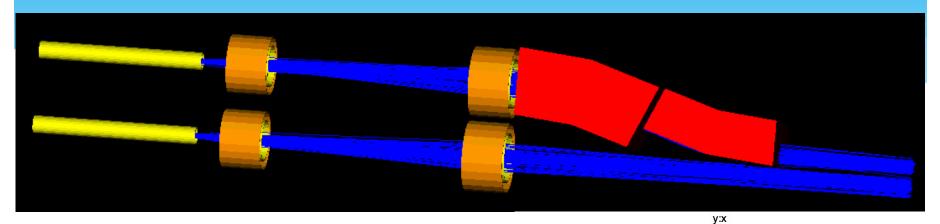


- RF cavity f=108 MHz
- M Length: 2m
- Cavity reduces the longitudinal size, also cuts some muons out
- Longitudinal emittance stable at 9.5 mm

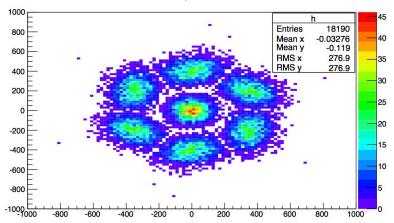




Funnel



Transmission 92%



Final output

- **EmitT** = 6.6 mm
- **EmitL** = 10.5 mm
- Beam time distribution SigmaT=0.9 ns
- Total length: 120 m
- ▼ Total transmission = 86.6% (5 sigma, no decay)

Summary and Further works

- The output emittance can reach the requirements of later cooling.
- M Longitudinal merge with pillbox cavities
- Matching to the cooling channels, both pre-merge and post-merge.